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DROUGHT—INDUCED CHANGES IN A SANDY GRASSLAND COMPLEX IN THE GREAT HUNGARIAN PLAIN

L. KÖRMÖCZI

Department of Ecology, József Attila University
H-6701 Szeged, P. O. B. 659, Hungary

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Abstract

Changes in floristic composition, which were induced by precipitation pattern, were detected in the sandy grassland communities existing in varied relief. The averages of characteristic indicator values W of three associations, such as the *Festucetum vaginatae, Potentillo-Festucetum pseudovinae* and *Molinio-Salicetum rosmarinifoliae,* were different which also reflected in the character, speed and intensity of their response to the fluctuations of precipitation pattern. The successive alteration of W-average was the most intense in the case of mesic grassland, and slight in dry grasslands. It had not any trend in *Festucetum vaginatae.*

The most pronounced changes in physiognomy appeared with the *Milinio-Salicetum rosmarinifoliae,* while that of the communities of extremely dry sand hills was only slight.

Key words: climatic changes, fluctuation, ordination, secondary succession, water supply

Introduction

Structural changes within a community are governed by environmental factors, life cycles of constituent populations, and their interference patterns. The effect of physiographic processes was studied for instance by OLSON (1958) and TAMURA et al. (1986) and that of climatic changes by ORR and EVENSON (1986), ROSEN (1985) and ROUNDY (1985). The examination of biotic processes included regeneration fluctuations of populations (BARCLAY-ESTRUP, 1970; BILLINGS and MARK, 1961; COUPLAND, 1974; WATT, 1947), competitive interactions (MULLER, 1974; CLATWORTHY, 1960; DE WIT, 1960), changes in biomass structure (SYMONIDES and BOROWIECKA, 1985), the impact of herbivores (BROWN, 1982; MURDOCH et al., 1972; STINSON and BROWN, 1983; WATT, 1981) or human interference (e.g., HOKKANEN and RAATIKAINEN, 1977; LINDHOLM and NUMMELIN, 1983; ROSEN, 1984).

Some of the factors influencing the vegetation dynamics involve heavy damage (e.g., human effect, intensive grazing), which lead to quick structural change, and induce very diverse successional pathways depending on intensity of the disturbance and on the presence of propagules of colonizing populations. Irregularities in climatic parameters may also cause quick changes in vegetation structure, when they have extreme values for a long time. These, however, do not induce new successional pathways, but rather accelerate the natural ones, or cause fluctuations or retrogressive developments in vegetation pattern.

The effect of precipitation (and its spatial and temporal distribution) is of great importance especially in xerothermic circumstances (HARPER, 1977), where the water supply is one of the limiting factors. Long precipitation-poor periods developing (sometimes lasting several years) may cause quick and serious structural change. In this paper an effect of such periods in a sandy grassland complex was studied. Particular attention was focused to the quality and speed of the structural change with respect to different plant communities.

Material and Methods

Investigations were carried out in the Kiskunság National Park (Hungary) between 1981 and 1988. The experimental area was a 2.4 ha portion of a sandy pasture. This area was free of grazing since 1976, but earlier it was grazed moderately by cattle. Varied relief with the maximum elevation differences of about 3 m, supports four characteristic associations; three sandy grassland communities (the *Brometum tectorum, Festucetum vaginatae,* and *Potentillo-Festucetum pseudovinae),* and a mesic dune-slack community of the *Molinio-Salicetum rosmarinifoliae* (nomenclature after SOÓ, 1964.) A more detailed description of the communities and the characteristics of the habitats are given by KÖRMÖCZI et al. (1981) and KÖRMÖCZI (1983).

The phytosociologic relevés were derived from 13 permanent plots of representative stands. The number of plots per community was proportional to the total area covered by them. *(Festucetum vaginatae:* 3 plots; *Potentillo-Festucetum pseudovinae:* 7 plots; Molinio-Salicetum rosmarinifoliae: 3 plots.) Thus no records were made in the *Brometum tectorum* because of its very small area.

The relevés were recorded from 2×2 m quadrats; relative cover values of the species in the relevé plot were scored in a late spring period (end of May until beginning of June) in each studied year in order to eliminate effect of seasonal fluctuations in vegetation.

Multivariate statistical analyses were used to evaluate the collected data. Cluster analysis was based on Euclidean distance and group average linkage algorithm (PODANI, 1980). Principal component analysis (PCA) based on correlation coefficient was also used (PIELOU, 1984). The 13 plots were divided into three groups (associations) on the basis of the cluster analisys of 1981-relevés.

For characterizing the changes of vegetation I used the TWR indicator values developed by ZÓLYOMI et al. (1967) that refer to temperature (T), water (W) and soil acidity (R) demand of species. Averages of these indicator values were calculated for particular years weighting by proportional coverage of species.

The actual climadiagram of the studied years was constructed on the basis of data from Kecskemét Meteorological Station. The monthly mean temperature and amount of precipitation in 1977—1988 were plotted.

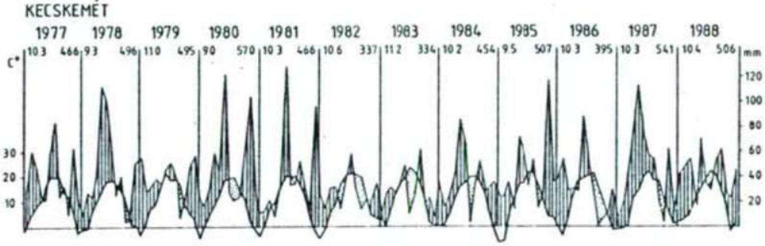

Fig. 1. Walter-Lieth diagramme of climate of the studied years based on data from the Kecskemét Meteorological Station

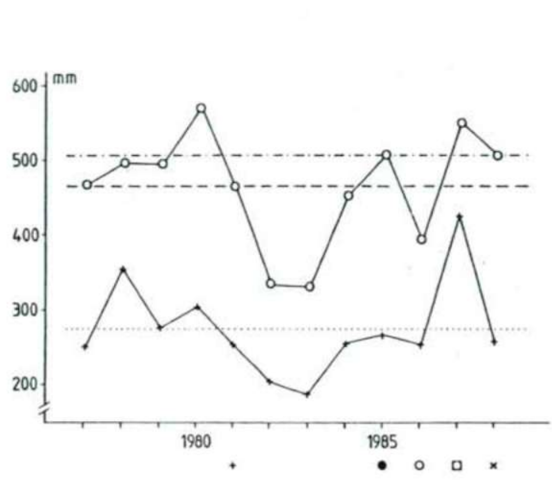

Fig. 2. Annual precipitation sum (o) and average (— — —) for the years 1977—1988 and 50-year average (— . —) in mm, and precipitation sum March-August (+) for years in question and average (...). Signs indicating the sampling years (1981: + ;1985:○:1986:●;1987:□;1988:x) are used in Fig. 3. and 4.

The mesoclimate pattern of the experimental-area between 1977 and 1988 is shown in Figure 1. The climate of the Kiskunság region (Great Hungarian Plain) is semiarid-continental, the average annual precipitation is about 500 mm, and the annual mean temperature is 10.3 C. The climate of the early period of the examination term was similar to the many-year average. But according to the Figure 1 the precipitation was very low during the period beginning in 1982 and especially in 1982—1984, which is shown markedly by drought periods in summer. Figure 2 presents data on annual rainfall and summer rainfall from March—August and clearly shows the 1982—1984 period with a precipitation deficit, but the summers were dryer than average from 1981 to 1986. The decrease in the average of 12-year annual precipitation compared with the 50-year average included a lack of important winter precipitation. This very unpleasant climatic effect imposed such a strong stress on vegetation, that it became a controlling factor of vegetation changes.

Results

Tables 1—3. show the summary of phytosociological relevés from experimental years. Species presences, life forms (SOÓ, 1980) and indicator values (ZÓLYOMI, 1967) are presented.

The studied associations, altough supported by different habitats, show many common features. Their species number per sample is low, which also can be ascribed to small size of the sampling plots. As compared with the 126 species occurring in the whole experimental area (GALLÉ et al., 1985) the average number of species per plot varied between 7—17. The total number of species in a community was, however, considerably high. The average species number in the *Festucetum vaginatae* samples varied between 7—13, but the cumulative species number (all species in all samples of the association) was 11—24 in the spring season and during a particular

Table 1. Summary of phytosociological relevés from the experimental years for *Festucetum-vaginatae* association. Life forms, presences and indicator values of species are presented. Also the weighted averages of indicator values for particular years are given.

	life forms	presence					indicator values		
		1981	1985	1986	1987	1988	T	W	R
Onosma arenaria	H	+					6	2	4
Leontodon autumnalis	H	+	+	+			5	6	0
Carex stenophylla	G	+	+	+	+	+	5	1	4
Eryngium campestre	H	+	+	+	+	+	7	2	4
Euphorbia segueriana	H	+	+	+	+	+	6	1	4
Festuca pseudovina	H	+	+	+	+	+	5	2	0
Festuca vaginata	H	+	+	+	+	+	6	0	5
Potentilla arenaria	H	+	+	+	+	+	6	1	5
Medicago minima	Th	+	+	+		+	7	2	4
Cynodon dactylon	G(H)	+		+	+	+	6	3	0
Secale silvestris	Th	+		+	+		5	0	5
Cerastium semidecandrum	Th		+				6	3	0
Myosotis arvensis	TH		+				5	3	0
Arenaria serpyllifolia	Th		+	+	+		5	1	3
Bromus squarrosus	Th		+	+	+		7	2	4
Achillea millefolium	H		+	+	+	+	5	3	0
Galium verum	H		+	+	+	+	5	3	4
Koeleria glauca	H		+	+	+	+	5	1	0
Silene otites	H		+	+	+	+	5	2	4
Thymus degenianus	Ch		+	+	+	+	-	-	-
Carex liparocarpos	G		+		+		6	3	4
Poa bulbosa	H		+		+	+	6	2	4
Polygonum arenarium	Th			+			6	0	0
Silene conica	Th			+			6	1	4
Calamagrostis epigeios	H-G			+			5	1	4
Minuartia glomerata	Th			+			5	2	5
Minuartia verna	H-Ch			+	+		4	2	4
Dianthus pontederae	H			+	+	+	6	2	4
Tragopogon dubius	TH			+	+	+	6	4	0
Kochia laniflora	Th			+	+	+	5	1	0
Teucrium chamaerdys	Ch				+		6	2	4
Poa angustifolia	H				+		5	3	4
Stipa capillata	H					+	6	2	4
T average		5.85	5.66	5.57	5.52	5.60			
W average		1.78	1.68	1.92	1.88	1.93			
R average		4.74	4.51	4.55	4.62	4.64			
species number		11	19	24	23	17			

Table 2. Summary of phytosociological relevés from the experimental years for *Potentillo-Festucetum pseudovinae* association. (For legend see Table 1)

	life forms	presence					indicator values		
		1981	1985	1986	1987	1988	T	W	R
Bromus tectorum	Th	+					7	2	0
Molinia coerulea	H	+	+				5	7	0
Plantago lanceolata	H	+	+	+	+		5	4	0
Tragopogon dubius	TH	+		+		+	6	4	0
Achillea millefolium	H	+	+	+	+	+	5	3	0
Carex stenophylla	G	+	+	+	+	+	5	1	4
Dianthus pontederae	H	+	+	+	+	+	6	2	4
Eryngium campestre	H	+	+	+	+	+	7	2	4
Euphorbia segueriana	H	+	+	+	+	+	6	1	4
Festuca pseudovina	H	+	+	+	+	+	5	2	0
Galium verum	H	+	+	+	+	+	5	3	4
Potentilla arenaria	H	+	+	+	+	+	6	1	5
Thymus degenianus	Ch	+	+	+	+	+	—	—	—
Veronica prostrata	Ch	+	+		+		6	2	4
Cynodon dactylon	G(H)	+		+	+	+	6	3	0
Holoschoenus vulgaris	G	+		+	+	+	6	6	4
Ononis spinosa	H-Ch	+		+	+	+	5	3	0
Arenaria serpyllifolia	Th		+				5	1	3
Cerastium semdecandrum	Th		+				6	3	0
Taraxacum officinale	H		+				0	5	0
Leontodon autumnalis	H		+	+			5	6	0
Medicago minima	Th		+			+	7	2	4
Euphorbia cyparissias	H(G)		+	+	+	+	5	3	0
Falcaria vulgaris	Th-TH		+	+	+	+	7	2	4
Festuca vaginata	H		+	+	+	+	6	0	5
Koeleria glauca	H		+	+	+	+	5	1	0
Silene otites	H		+	+	+	+	5	2	4
Stipa capillata	H		+	+	+	+	6	1	4
Trifolium montanum	H		+	+	+	+	5	3	4
Colchicum arenarium	G		+		+		7	2	4
Poa bulbosa	H		+		+		6	2	4
Anchusa officinalis	TH-H			+			6	3	0
Equisetum ramosissimum	G			+			0	2	0
Silene conica	Th			+			6	1	4
Phleum pratense	H			+	+		5	5	0
Poa angustifolia	H			+	+		5	3	4
Scabiosa ochroleuca	H			+		+	6	2	4
Erysimum diffusum	TH—H	+			+	+	5	2	4
Calamagrostis epigeios	H-G			+	+	+	5	3	0
Teucrium chamaedrys	Ch			+	+	+	6	2	4
Carex liparocarpos	G				+		6	3	4

Table 2. (cont.)

	life forms	presence					indicator values		
		1981	1985	1986	1987	1988	T	W	R
Alkanna tinctoria	H				+		7	0	5
Marrubium peregrinum	H-Ch				+		7	3	0
Minuartia verna	H-Ch				+		4	2	4
Myosotis stricta	Th				+		5	2	0
Secale silvestris	Th				+		5	0	5
Verbascum phoeniceum	H				+		6	2	4
Veronica spicata	H-Ch				+		5	1	4
Hieracium auriculoides	H				+	+	5	5	3
Medicago falcata	H				+	+	6	3	4
Dianthus serotinus	H					+	6	0	5
Onosma arenaria	H					+	6	2	4
Poa bulbosa	H					+	6	2	4
Rhinanthus borbási	Th					+	—	—	—
Trinia ramosissima	H					+	6	4	4
T average		5.43	5.39	5.56	5.40	5.47			
W average		2.07	2.12	2.05	1.93	1.97			
R average		4.38	4.14	4.14	4.10	4.14			
species number		17	25	30	38	32			

Table 3. Summary of phytosociological relevés from the experimental years for *Molinio-Salicetum rosmarinifoliae* association. (For legend see Table 1)

	life forms	presence					indicator values		
		1981	1985	1986	1987	1988	T	W	R
Leontodon autumnalis	H	+			+		5	6	0
Cynodon dactylon	G(H)	+				+	6	3	0
Molinia coerulea	H	+	+			+	5	7	0
Achillea millefolium	H	+	+	+	+	+	5	3	0
Galium verum	H	+	+	+	+	+	5	3	4
Holoschoenus vulgaris	G	+	+	+	+	+	6	6	4
Ononis spinosa	H-Ch	+	+	+	+	+	5	3	0
Plantago lanceolata	H	+	+	+	+	+	5	4	0
Poa angustfolia	H	+	+	+	+	+	5	3	4
Potentilla arenaria	H	+	+	+	+	+	6	1	5
Salix rosarinifolia	M		+				5	1	3
Schoenus nigricans	HH	+	+	+	+	+	5	9	5
Polygala comosa	H-Ch	+	+	+	+	+	5	1	4
Arenaria serpyllifolia	Th		+				5	1	3
Cerastium semidecandrum	Th		+				6	3	0
Senecio vernalis	Th-TH		+				—	—	—
Centaurea pannonica	H		+		+		5	6	0
Veronica prostrata	Ch		+		+		6	2	4
Calamagrostis epigeios	H-G		+	+	+	+	5	3	0
Euphorbia cyparissias	H(G)		+	+	+	+	5	3	0
Euphorbia segueriana	H		+	+	+	+	6	1	4
Silene otites	H		+	+	+	+	5	4	2
Thymus degenianus	Ch		+	+	+	+	—	—	—
Koeleria glauca	H		+		+	+	5	1	0
Equisetum ramosissimum	G			+			0	2	0
Medicago minima	Th			+			7	2	4
Myosotis stricta	Th			+			5	2	0
Potentilla reptans	H			+			6	0	3
Tragopogon dubius	TH			+			5	1	4
Verbascum lycnitis	TH			+	+		5	1	4
Eryngium campestre	H			+		+	7	2	4
Carex liparocarpos	G			+	+	+	6	3	4
Carex stenophylla	G			+	+	+	5	1	4
Festuca pseudovina	H			+	+	+	5	2	0
Scabiosa ochroleuca	H			+	+	+	6	2	4
Teucrium chamaedrys	Ch			+	+	+	6	2	4
Minuartia glomerata	Th				+		5	2	5
Poa bulbosa	H				+		6	2	4
Veronica praecox	Th				+		6	2	3

Table 3. (cont.)

	life forms	presence					indicator values		
		1981	1985	1986	1987	1988	T	W	R
Dianthus pontederae	H				+	+	6	2	4
Erysimum diffusum	TH-H				+	+	5	2	4
Hieracium auriculoides	H				+	+	5	5	3
Trinia ramosissima	H				+	+	6	4	4
Viola arvensis	Th				+	+	5	4	0
Plantago maritima	H				+	+	5	6	5
Rhinanthus borbási	Th					+	—	—	—
Seseli annuum	Th-TH					+	6	4	1
T average		5.11	5.07	5.30	5.22	5.31			
W average		4.17	4.30	3.16	3.35	3.58			
R average		4.05	4.13	4.15	4.02	3.98			
species number		14	21	26	33	33			

year amounted to 45. For the *Potentillo-Festucetum pseudovinae* the average species number was between 17—38, while those of the *Molinio-Salicetum rosmarinifoliae* between 7—17 and 14—33, respectively. The low species number per sample and high number of species in a community reflect a spatial variability of the experimental area.

An important feature of changes is that the number of species in each community increased in the course of experimental years, but in the case of xeric associations, especially in *Festucetum vaginatae,* some decrease was observed is the last year.

Since the associations in question were recognized and studied before the fencing of the experimental area (BODROGKÖZY and FARKAS, 1981; KÖRMÖCZI et al., 1981) and since this part of pasture field had been moderately grazed (but only until 1976), it was possible that the species changes between 1981 and 1988 were caused primarily not by the exclosure of animals but by drought period. It is supported well by the changes of average value of W, while those of T and R didn't show any trend (see tables 1—3). (The W-averages differ in the three associations from each other, but it reflects to microclimatic effects of secondary importance in this case — KÖRMÖCZI et al., 1981.)

The marked alterations occurred in *Molinio-Salicetum rosmarinifoliae,* i.e. the greatest decrease of average water demand can be detected in this case. The W-values of disappearing species were higher than those of appearing ones. The W-average of species disappearing until 1987 is 4.33, while that of entering species is 2.13. This trend can be seen in case of *Potentillo-Fesucetum pseudovinae,* as well, though the W-average decreased less.

In the association of extreme dry sites (*Festucetum vaginatae*) the changes of average water demand couldn't be detected, but the species number increased (Table 1) similarly to the other two associations.

It can be mentioned, however, that only few species disappeared from the set of the first year in case of either communities but the proportions of cover changes considerably, and the appearing species were partly annuals, and partly perennials with smaller water demand (Tables 1—3).

Discussion

One of the most important background factors in the development of structure of a sandy grassland is water supply (FEKETE et al., 1979; KOVÁCS-LÁNG, 1974; HOKKANEN and RAATIKAINEN, 1977). The biotic communities in these habitats are affected by the climate to a different degree, and with different biotic communities different elements of the climate can be considered as controlling (GYÖRFFY and KÖRMÖCZI, 1987 a; b).

Water is a direct limiting factor for the vegetation. The amount of precipitation in vegetation periods is of primary importance, while the deviations in monthly mean temperature, monthly maximum and minimum temperature from the many-year average were not considerable. It became clear that the monthly precipitation fluctuations might have played an important role in generating the structural changes in vegetation (VAN DER MAAREL, 1981).

In the course of the last 12 years, 1982 was a marking point characteristic by its very high precipitation deficit, which lasted for three years, and only in winter of 1985 was there a larger water supply available (Fig. 1). Also the subsequent yeras

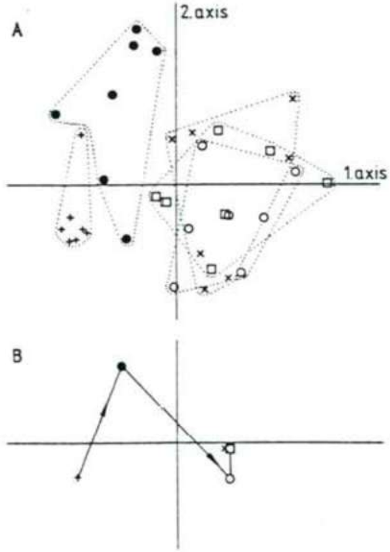

Fig. 3. The PCA of revelés made in different years in *Potentillo-Festucetum pseudovinae* association (A). Trajectories of the centres of revelés belonging to the same year (B). For legend see Fig. 2.

were rather precipitation-poor (below the average; especially in the vegetation period). The response of the studied communities manifested in appearance of some new colonizing species and in alteration of cover proportions. The new colonizer species were rather annuals or perennials with smaller water demand.

The changes within the studied plant communities were following different pathways. They were uniformly within the *Potentillo-Festucetum pseudovinae*. In terms of the ordination results the shifts of objects were mainly synchronous. The points belonging to the same year remained together, and considerable structural changes could not be detected in the last three years. Figure 3B shows the trajectories of the centres of objects belonging to the same year. The strongest correlation to the average W-values can be detected with the frist component scores.

I could not find a close correlation between W-average of assocations and sum of annual precipitation. It was negative in the case of *Potentillo-Festucetum pseudovinae,* but positive (but very weak: r = 0.28) when was calculated with the precipitation of previous years. The correlation was, however, stronger (r = 0.62) between the

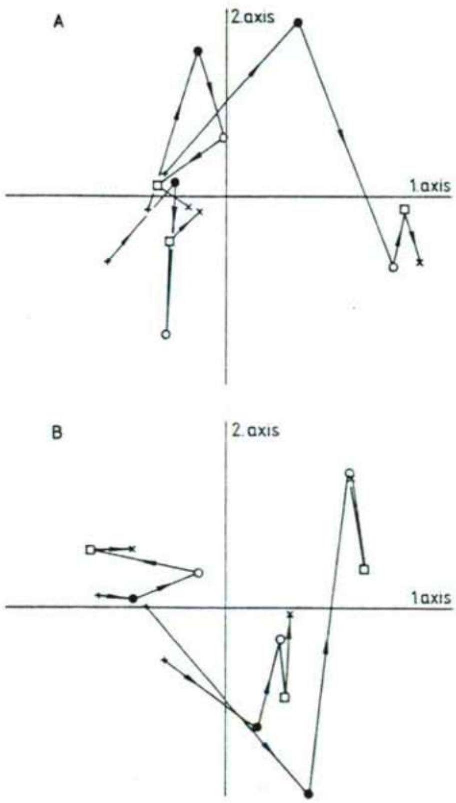

Fig. 4. The PCA of revelés made in different years in permanent plots of the studied associations. A. *Festucetum vaginatae,* B. *Molinio-Salicetum rosmarinifoliae.* For legend see Fig. 2.

decrease of W-average and time. The situation is similar with *Molinio-Salicetum rosmarinifoliae,* but it had also a weak positive correlation ($r=0.24$) between W-average and precipitation of actual years. Its correlation with time was 0.65.

Two stands of *Festucetum vaginatae* association show narrow range along the frist axis but the movement (the trajectories) of the third one is similar to that of *Potentillo-Festcetum pseudovinae* (Fig. 4A). In the cluster analysis these three stands formed a tight cluster but later the character of one of them proved to be similar to that of *Potentillo-Festucetum pseudovinae.* The communities of the other two sites were in extreme dry conditions from the earliest recording, that is why they were hardly influenced by drought.

There is a similar situation with *Molinio-Salicetum rosmarinifoliae.* Also the three stands showed a tight cluster for the first experimental year, but later they diverged, two stands showed the change depending on the water deficit (there is a strong correlation between the first component scores and average W-values for the particular years, too). The small fluctuation of the third stand is the result of its topografic position. It is situated in the deepest wind groove, the water conditions of which were the most favourable, and as a consequence of this the above mentioned community could tolerate the precipitation deficiency here.

The correlation between W-average and time and between W-average and lst PCA axis scores reflects to the temporal change of water condition of the studied associations. But it does not support the direct connection between structural changes and precipitation. Maybe, the effect of precipitation deficit is manifested by the decrease of water table, or it is superposed on water table decrease. (The average water table was about 70 cm under the soil surface in 1978 at the deepest point of the study area, but it was under 3.0 m in 1986. KÖRMÖCZI ined.)

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